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RECOVERY POTENTIAL ASSESSMENT OF PURE NATIVE[1] WESTSLOPE CUTTHROAT TROUT, ALBERTA POPULATION

Photo credit: Jim Stelfox

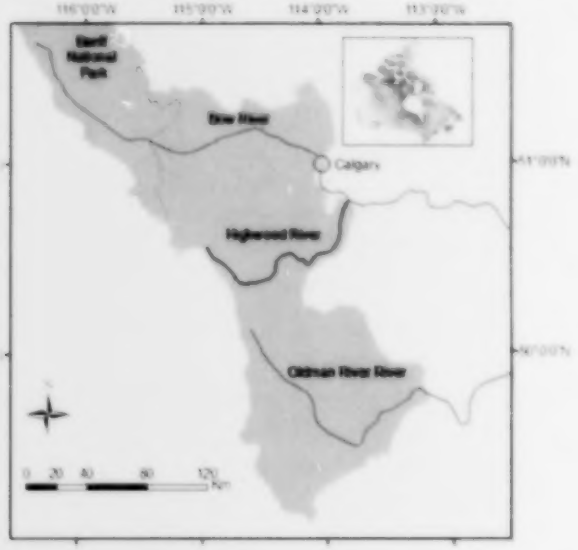

Figure 1. General distribution of pure native (not stocked) populations of Westslope Cutthroat Trout in Alberta.

Context:

*In November 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Alberta population of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) as Threatened because the pure native, non-stocked, populations had been reduced by almost 80% as a result of over-exploitation, habitat degradation and hybridization/competition with introduced non-native trout (COSEWIC 2006). Remaining pure Westslope Cutthroat Trout persist mainly as severely fragmented, remnant headwater populations in southwestern Alberta, primarily in the upper South Saskatchewan River drainage (Bow and Oldman rivers).*

Westslope Cutthroat Trout are a popular recreational sport fish which contributes to local economies. They are prized by the local angling community because they are a wild native trout, easy to catch and resilient to catch-and-release. Frequently they are the only native trout throughout much of their range in western Canada and are viewed as an indicator species of general ecosystem health because of their restricted habitat needs.

This subspecies is now being considered for legal listing under the Species at Risk Act *(SARA). In advance of making a listing decision, Fisheries and Oceans Canada (DFO) Science has been asked to undertake a Recovery Potential Assessment (RPA). This RPA provides a summary of current understanding related to the distribution, abundance and trend of pure native Westslope Cutthroat Trout*

[1] In this document, pure native populations are assumed to be non-stocked populations.

in Alberta along with recovery targets and times. The current state of knowledge about habitat requirements, threats to both habitat and Westslope Cutthroat Trout, and measures to mitigate these impacts, are also included. This information will be used to inform both scientific and socio-economic elements of the listing decision, development of a recovery strategy and action plan, and for assessing SARA Section 73 permits.

SUMMARY

- In Alberta, pure native Westslope Cutthroat Trout have declined in numbers over the past century. Of the 50 extant populations, which are estimated to contain a total of less than 5,000 mature individuals, eight (16%) are currently thought to have a low chance of recovery.
- Most, if not all, current populations are restricted to the extreme headwaters of a few major tributaries and upper mainstem of the Bow River drainage and the upper basin of the Oldman River drainage.
- All geographic areas where pure Westslope Cutthroat Trout are currently found may be critical for the long-term survival and recovery of this subspecies.
- Redds created by females for spawning and the initial development of eggs and alevins meet the SARA definition of residence.
- The recovery goal is to protect and maintain all remaining pure native, non-stocked, populations of Westslope Cutthroat Trout in Alberta, each containing at least their current number of fish, with their historical degree of connectivity within drainage systems (except where it would permit invasive non-indigenous species to establish) throughout their current range to ensure their persistence until at least 2020. The aim over the long term is to recover populations within their historic range, where possible.
- Invasive non-indigenous species, habitat damage and loss, and climate change pose significant threats to the long-term survival and recovery of pure Westslope Cutthroat Trout. Overexploitation was an important threat historically, but now is relatively minor.
- Important mitigation measures that would improve the current likelihood of survival and recovery of this subspecies include protection of pure native populations from hybridization and competition with non-indigenous species, protection, restoration and enhancement of their habitat, especially by restoring watershed ecological function, and public education (in decreasing order of importance).
- Activities that have a moderate or higher probability of jeopardizing the survival or recovery of pure native Westslope Cutthroat Trout in Alberta are not recommended. Allowable harm from controlled recreational angling (catch-and-release or harvest) may be considered. Research activities should be allowed if they are beneficial to the subspecies and will not jeopardize the survival or recovery of a population.

BACKGROUND

Rationale for Assessment

The Committee on the Status of Endangered Wildlife in Canada COSEWIC designated the Alberta population of Westslope Cutthroat Trout as Threatened in 2006 and it is now being

considered for listing under the *Species at Risk Act* (SARA). When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of the DFO is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the designatable unit, the threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including recovery planning. If listed, decisions made on permitting of harm and in support of recovery planning need to be informed by the impact of human activities on the species, alternatives and mitigation measures to these activities, and the potential for recovery. The information and scientific advice provided in this document will inform the listing decision, issuance of Section 73 permits and recovery planning.

Species Biology and Ecology

Westslope Cutthroat Trout have dark spots on a lighter background and bright orange-red slashes beneath the lower jaw, which give the species its name. Their fork length (FL) is typically 150-230 mm and rarely exceeds 410-460 mm (Cleator *et al.* 2009). Resident and fluvial (i.e., live in rivers and migrate elsewhere in the mainstem or to tributary streams to spawn) populations were once common in Alberta, while adfluvial (i.e., reside in lakes and migrate up- or down-stream into rivers or streams to spawn) populations were less so. Migratory populations have largely disappeared from Alberta; resident populations are now primarily the only remaining form.

Seasonally, Westslope Cutthroat Trout often move in early- to mid-summer in search of suitable feeding habitat. In late summer and early fall, they begin to seek deep pools and/or groundwater discharge areas for overwintering in response to decreasing water temperatures and ice formation. As water temperatures rise and days lengthen in late winter-early spring they move to spawning areas, after which they return to their summer habitat. Resident Westslope Cutthroat Trout show some spawning fidelity to natal streams. Genetic differentiation among pure native Westslope Cutthroat Trout populations in Alberta is substantial at the level of streams and lakes, rather than between major watersheds, with little gene flow even in adjacent populations.

The mating system of Westslope Cutthroat Trout is typical of salmonids in which spawners migrate to or are resident in small, low gradient, natal streams where males compete for access to females. Females reach sexual maturity at 150-280 mm FL, between 3 and 5 years of age, and males at 110-210 mm FL, between 2 and 4 years of age (Cleator *et al.* 2009). Spawning typically occurs in May and June in Alberta, usually when water temperatures approach 10°C. Sex ratio on the spawning grounds generally favours males in resident headwater populations. Females may contain between about 200 and 1500 eggs depending on their size and larger females also produce larger eggs, which improves their survivability. There appear to be very few repeat spawners and post-mating mortality may be significant for males.

Eggs and alevins remain in the spawning gravels until the fry emerge in early July to late August. They quickly move to slower-moving waters with cover, commonly in shallows near banks and side channels. Depending on the productivity of the stream, juveniles remain in their natal streams from 1 to 4 years. They may be relatively sedentary during this period or range in response to water levels, stream temperatures or the availability of food. Survival is likely lowest from the egg to juvenile stage when they are sensitive to environmental degradation, especially sedimentation and dewatering, and predation by piscivorous fishes. When riparian cover is lacking, adults are vulnerable to raptors, mustelids and other predators. Westslope Cutthroat Trout seldom attain 10 years of age.

The diet is mostly comprised of chironomid larvae for young-of-the-year fry and terrestrial and aquatic invertebrates for older juveniles and adults. Even when forage fish are available, Westslope Cutthroat Trout are not highly piscivorous.

Hatchery-reared Cutthroat Trout and several non-indigenous salmonid species, and hybrids, including Rainbow Trout (*Oncorhynchus mykiss*) and Yellowstone Cutthroat Trout (*O. c. bouiveri*), have been introduced widely throughout the native range of the Westslope Cutthroat Trout. These stocking activities have affected the genetic integrity of pure populations of Westslope Cutthroat Trout as they will hybridize with the introduced fish. Introgressive hybridization with Rainbow Trout is most pervasive. COSEWIC assessed the status of only genetically pure populations of Westslope Cutthroat Trout that occur within their native range in Alberta. They did not assess populations that were known to be hybridized with other trout species or those that had been introduced into waterbodies in which native Westslope Cutthroat Trout populations were previously absent.

ASSESSMENT

Historic and Current Abundance and Trends

Historically, Westslope Cutthroat Trout likely occurred in abundant numbers in about 274 streams/rivers from the Bow River to the Alberta-Montana border (Cleator *et al.* 2009). Numbers of fish began to decline following the arrival of the Canadian Pacific Railway in 1883, primarily as a result of overexploitation and later displacement and hybridization with stocked non-indigenous salmonids. Now only about 50 streams (18% of the original 274) in Alberta are known or suspected to contain pure strains of Westslope Cutthroat Trout (Table 1). Given the limited sample sizes that have been used for genetic testing to date, it is possible that as sample sizes increase in the future some of the remaining "pure strain" populations will be identified as hybrid populations. Most of the remaining streams average about 8 km in length and contain an average of 100 adults (range: 30-200), therefore the remaining pure native populations are estimated to contain no more than 5,000 adults in total. It is likely the genetically pure fluvial and adfluvial forms have been lost from the Bow and Oldman drainages and essentially only small stream-resident populations now remain. Some of the remaining populations are likely stable, but available information suggests that many others are smaller than historic levels or have become extirpated. Some contain only 30 or fewer mature fish. Eight (16%) of the extant populations are currently thought to have a low chance of recovery (Table 1).

Historic and Current Distribution and Trends

The native range of this subspecies is thought to have been the Bow and Oldman drainages of the South Saskatchewan River, from the headwaters downstream to the plains. They may also have occurred in the headwaters of the Milk River. Over the past century, pure native Westslope Cutthroat Trout disappeared from most of their native range in Alberta as a result of overexploitation, hybridization and competition with stocked non-indigenous salmonids, and habitat damage and loss. It is estimated that the total proportion of the historical distribution that remains occupied is at most 20%, with an area of occupancy of less than 2,000 km^2 (Cleator *et al.* 2009). Pure populations in the Bow drainage today are generally small and restricted to the extreme headwaters of a few major tributaries and upper mainstem. They are estimated to now occupy less than 5% of their native range in the Bow drainage, except in Banff National Park where they occupy about 20-30% (Cleator *et al.* 2009). In the Oldman River drainage, they still

occur in the upper basin but not in the mainstem east of the mountain front or in most accessible tributaries. Their current status in the Milk River is unknown: only a single specimen has ever been reported, and a more recent survey failed to find any specimens. By any measure, the current distribution of pure native Westslope Cutthroat Trout in Alberta is severely fragmented.

Information to Support Identification of Critical Habitat

This subspecies thrives in cold, clean streams with abundant pool habitat and cover, containing features such as undercut banks, pool-riffle habitat and riparian vegetation. Westslope Cutthroat Trout prefer stream temperatures of 9-12°C and their upper incipient lethal temperature is just 19.6°C (Cleator *et al.* 2009). They have very strict habitat requirements for various life-history stages. Preferred spawning sites are located in small, low-gradient streams with cold well-oxygenated water and clean unsilted gravels in close proximity to good cover, such as large woody debris, boulders or bedrock. Spawning females seek out the downstream edge of deep pools. Juvenile rearing habitat consists of small streams that remain wet during low flow and have a diversity of cover. Young fish select shallow riffles or backwater habitat, often right at the land-water boundary. The presence and quantity of groundwater influx, deep pools and the absence of anchor ice are important components of overwintering habitat. Juveniles use sheltered waters with cover provided by boulders and other instream structures, or sloughs and beaver ponds. Availability of pool habitat may limit juvenile productivity, as well as adult population density. Riparian cover often serves as an important source of terrestrial invertebrates, for food, in summer.

Survival and recovery of Westslope Cutthroat Trout depends on the availability of habitat for key components of the life cycle: overwintering, spawning, juvenile rearing and summer feeding. Cold clean water with varied instream structure and riparian cover, which provide both complexity and areas of refuge, clean gravel for spawning, shallow low-velocity areas for juvenile rearing, pools for adult holding, and deep pools and/or groundwater discharge areas for overwintering, all connected by passable migration routes (because these habitat features are rarely found in the same locations), are all essential characteristics of their habitat. The availability, quality, quantity and distribution of overwintering habitat is frequently limited and, therefore, disproportionately important habitat for survival and recovery.

Given that the current distribution of pure native Westslope Cutthroat Trout is severely fragmented and the remaining fragments are very small, it is reasonable to assume that all the geographic areas where they are currently found may be critical for their survival or recovery. Efforts to recover the Alberta population may require rehabilitation of whole watersheds, including streams or parts of streams, within the historic range so that Westslope Cutthroat Trout populations can recolonize former, now-abandoned range. The value of these geospatial areas depends on their ability to provide the functional attributes necessary for overwintering, spawning, juvenile rearing, summer feeding and migration/movements, which is only possible by retaining or reinstating the natural hydrological regime at the watershed scale, in association with riparian areas. Removal of barriers to re-establish connectivity that historically existed within drainage systems would be counterproductive in some cases, as it would further facilitate hybridization and competition with non-indigenous salmonids, which already pose a serious threat to pure strains.

Residence

During the spawning season, female Westslope Cutthroat Trout dig redds in clean gravel into which they release their eggs and males release sperm. The fertilized eggs fall into the spaces

in the graveled depression. Most redds are abandoned by spawning adults within 48 hours, however the eggs, and later the alevins, remain in the substrate until the fry emerge in early July to late August. Most redds are found in lower-order tributaries in clean substrates, in close proximity to undercut banks or large woody debris, comprised of gravels, cobbles and/or pebbles, which are relatively unconsolidated and easily moved by spawning females. Overhead cover enhances the suitability of an area by providing cover and protection during redd construction and spawning, though Westslope Cutthroat Trout will also spawn in open sections of creeks. Areas of freshly deposited small and large gravels and cobbles may be critical for spawning, but it is likely that no single attribute is essential to redd site selection. Probably a combination of factors, including water velocity, water depth, temperature, cover, substrate permeability and substrate size, determines their locations. Though redds have been found to be remarkably similar among streams, they can be reliably identified only on the basis of where fish are seen spawning. If water flows are high and turbid during the spawning season, or scouring of the substrate occurs after spawning, this would hamper detection.

SARA defines a *residence* as "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Redds are created and used by Westslope Cutthroat Trout for spawning and development up until the fry emerge. Eggs, alevins and fry are critical components in the life cycle, therefore redds meet the SARA definition of residence.

Recovery targets

The recovery goal is to protect and maintain all remaining pure native, non-stocked, populations of Westslope Cutthroat Trout in Alberta, each containing at least their current number of fish, with their historical degree of connectivity within drainage systems (except where it would permit invasive non-indigenous species to establish) throughout their current range to ensure their persistence until at least 2020. The aim over the long term is to recover populations within their historic range, where possible.

A reasonable way forward to achieve this recovery goal might to be to prioritize recovery efforts for all remaining pure native populations (Table 1) based on their current size, importance and a realistic evaluation of their prognosis for survival and recovery (i.e., a triage approach). Some populations are relatively large and will likely survive over the long term with minimal protection. Other populations that are more at risk of extinction may require more aggressive recovery efforts. For populations with < 50 adults, which are on the brink of extinction, recovery efforts might be undertaken only if a useful approach can be developed and funding is available. Waters where populations that have already gone extinct could be re-stocked, but that ignores the loss of genetic diversity.

The populations listed in Table 1 are those in which the average of all fish tested was ≥ 0.99 proportion of Westslope Cutthroat Trout genome. Some of these populations may contain one or more individual fish with a slightly lower proportion of WSCT genome. Regardless, the conservation value of all these populations is high and protection and recovery efforts should be afforded to all of them.

Viability analysis suggests a Westslope Cutthroat Trout population must have about 470 adults to have a 50% probability of persistence for at least 40 generations (i.e., 120 – 200 years), and more than 4600 adults to have a 90% probability of long-term persistence (Cleator *et al.* 2009). For many, if not most, very small populations today it seems unlikely that it will be possible to facilitate population growth to a level that would ensure their long-term persistence. Yet small

headwater populations in Alberta have persisted historically which suggests they may have gone extinct repeatedly in the past, but were subsequently replenished by downstream populations. This hypothesis highlights the importance of re-forming metapopulations within connected systems in Alberta, which would allow persistence despite disturbance or changing environments, as long as it does not allow invasive non-indigenous species to enter systems where they do not already exist.

Threats to Survival and Recovery

Four general types of threats of anthropogenic origin (Table 2) have led to the decline in numbers of Westslope Cutthroat Trout in Alberta over the past 125 years: initially overexploitation, then the introduction of non-indigenous species and/or genotypes starting in 1913, and more recently habitat damage and loss and climate change. Currently the greatest threat is introgressive hybridization and competitive displacement from non-indigenous salmonid species.

Stocking of non-indigenous salmonids (e.g., Rainbow Trout, Brook Trout (*Salvelinus fontinalis*), Brown Trout (*Salmo trutta*) and Lake Trout (*Salvelinus namaycush*)) in Alberta has caused significant genetic (e.g., hybridization) and/or ecological impacts (e.g., displacement and competition) to native Westslope Cutthroat Trout populations, as well as predation of alevin, fry and subadults depending on the introduced species. Stocking of non-indigenous salmonids, might also introduce other threats such as parasites and disease. Increasing land use, degradation of habitat, and increasing water temperature resulting from climate change, will likely lead to increased hybridization and competition and reduce the opportunity for rescue effect (i.e., immigration from an outside source).

Human land-use activities related to resource extraction (i.e., oil and gas, forestry and mining), hydroelectric barriers and impoundments, agriculture, urbanization, road and rail infrastructure and recreation have heavily impacted the native range of Westslope Cutthroat Trout in Alberta. These anthropogenic activities have reduced population densities and have caused habitat damage and loss, thereby reducing the carrying capacity of the habitat available to remnant populations.

Current scenarios and models for climate change in southwestern Alberta predict a rise in temperatures that will intensify with time. Substantial changes in basin hydrology, channel morphology, riparian physical structure and streamflows are predicted, especially from the 2050s to 2080s and beyond. These changes will probably cause watershed deterioration, further reducing habitat quality and quantity especially in summer. Rising water temperatures may also affect the physiology, and thus the biology and ecology, of Westslope Cutthroat Trout.

Overharvest in the late 1800s and early 1900s contributed significantly to the decline of native stocks of Westslope Cutthroat Trout in Alberta. Over the past 20 years, fishing regulations have become increasingly more restrictive including the closure to harvest of some streams in the Bow and Oldman drainages and to angling during vulnerable overwintering periods and spawning migrations (November to June). Additionally, bait bans have been implemented to reduce the effects of hooking mortality. Where harvest of fish is allowed, typically there are large minimum-size limits to reduce the proportion of the population that is vulnerable to harvest. Several intensive Westslope Cutthroat Trout fisheries remain where conditions allow fish numbers and/or biomass to be maintained or increased while sustaining relatively high levels of fishing pressure. While the threat from angling has been significantly reduced, mortality can occur as a result of intentional (poaching) and unintentional (misidentification) illegal harvest. Overall, overexploitation is currently a relatively minor threat to this subspecies.

Limiting Factors for Population Recovery

Westslope Cutthroat Trout possess several intrinsic or evolved biological characteristics that may naturally influence or limit their potential for recovery: (1) preference for cold water with limited productivity, (2) requirement for watersheds that have suitable spawning areas, deep pools and/or groundwater discharge areas for overwintering and that don't have high sediment loads, and (3) small population sizes with variable numbers of spawners which makes them subject to stochastic events (e.g., epidemic disease, drought).

Mitigation and Alternatives

The following mitigation and alternative measures are specific to Westslope Cutthroat Trout. More generic measures or alternatives that could mitigate the impacts of threats should also be considered.

Invasive non-indigenous species: hybridization, competition and predation

Mitigation

- Prohibit stocking non-indigenous salmonids in waterbodies where pure native populations of Westslope Cutthroat Trout remain and no non-indigenous species occur.
- Carefully evaluate the costs and benefits before removing an existing control structure or barrier (e.g., culvert) in a waterbody containing a pure native population of Westslope Cutthroat Trout. Removing a structure may allow non-indigenous salmonids, especially Rainbow Trout, to move upstream and hybridize with Westslope Cutthroat Trout.

Alternatives

- Archive selected genetically pure stocks of Westslope Cutthroat Trout in appropriate waters with suitable habitat.
- Restore pure native Westslope Cutthroat Trout in some headwater areas where non-indigenous and hybridized fish also occur (stocking is not always necessary), if appropriate.
- Introduce barriers to isolate and protect pure populations above them when there is a threat of invasive non-indigenous species moving upstream. (This strategy may increase potential extinction risks due to stochastic environmental and demographic processes.)
- Educate the public about the risks to pure populations of Westslope Cutthroat Trout associated with hybridization and/or competition from non-indigenous salmonids, what measures they can take to help prevent it and the value of this trout species.

Habitat damage and loss: hydroelectric barriers and impoundments

Mitigation

- Mitigate habitat loss and changes in flow regimes resulting from hydroelectric dams and impoundments through changes to current operating conditions.
- Provide fish passage for Westslope Cutthroat Trout where appropriate.
- Incrementally restore habitat for pure Westslope Cutthroat Trout. In areas where a pure native population and an artificial or natural barrier downstream already exists, and suitable habitat is available below the barrier, a second barrier could be installed several kilometres downstream of the first, all non-indigenous and hybridized fishes cleared in that stretch of water and then the first barrier removed so that the pure Westslope Cutthroat Trout could extend their range downstream. Or, if removal of the first barrier is not possible, some fish could be transferred downstream from above the first barrier to between the two barriers. In areas where no pure native population currently exists, a barrier could be installed, the water

cleared of non-indigenous and hybridized fishes and then conservation stocking undertaken with pure Westslope Cutthroat Trout.

Alternatives

- Remove dams not in use that are barriers to connectivity within Westslope Cutthroat Trout metapopulations, unless it would allow invasive non-indigenous species to enter systems where they do not already have access.
- Prohibit the construction of new dams to prevent further loss of connectivity in areas where pure native Westslope Cutthroat Trout are known to occur, except where there is a threat of invasive non-indigenous species moving upstream.

Habitat damage and loss: oil and gas, forestry, mining, agriculture, urbanization, road and rail infrastructure and recreation

Mitigation

- Selectively remove, re-contour and re-vegetate roads that are not needed from watersheds, restore natural drainage, remove culverts and prevent access while the rights-of-way recover.
- In areas where pure native Westslope Cutthroat Trout are known to occur, prohibit activities that cause, or have the potential to cause, the following:
  - removal of riparian vegetation
  - removal of instream structure (e.g., woody debris and boulders)
  - significant sedimentation, especially during winter or spring
  - significant changes in water flow, especially during spring (when spawning and rearing occur) and winter (for holding habitat)
  - release of contaminants
  - significant changes in water temperature, total gas pressure, salinity or nutrient concentrations
- Educate the public about the risks to Westslope Cutthroat Trout associated with environmental destruction or degradation and what measures they can take to help prevent it.

Fishing

Mitigation

- Institute a program of severe fines for poaching of suspected and known pure native Westslope Cutthroat Trout, extensive advertising of the fines, enhanced officer presence at streams and strongly worded enforcement messages to reduce intentional illegal harvest, recognizing that differences exist between how national parks and areas outside national parks are managed (under Parks Canada and Alberta Government jurisdiction, respectively).
- Increase angler awareness of fish identification by distributing educational materials. In areas outside national parks, move toward requiring anglers to pass a mandatory test before they are permitted to harvest fish from eastern slopes waters in the South Saskatchewan River watershed that contain fish species, other than pure native Westslope Cutthroat Trout, that can be harvested.
- Regulate or encourage fishing practices that improve fish survival for catch-and-release fisheries, such as cutting lines of deeply-hooked fish and tight-line fishing.

Alternatives

- Encourage fish watching as an alternative to fishing.

Allowable Harm

Activities that have a moderate or higher probability of jeopardizing the survival or recovery of pure native Westslope Cutthroat Trout in Alberta are not recommended. Introductions of invasive non-indigenous species pose severe consequences to pure-strain populations, by negatively affecting all life stages (i.e., young-of-the-year, juvenile and adult fish) through hybridization, competition and predation and thus are a high risk to survival or recovery where pure remnant Westslope Cutthroat Trout populations remain. Land-use activities also have the potential to indiscriminately affect all three life stages making them more likely to jeopardize survival or recovery of a population. Those land-use activities that damage or destroy the functional components of habitat or negatively affect key life components of the life cycle (e.g., spawning, recruitment and survival) have a high risk to negatively impact Westslope Cutthroat Trout populations.

Recreational angling can be controlled by location, timing, severity (e.g., by bag limits and bait bans) and segment of the population affected (e.g., size limits), therefore it has the potential to target only one portion of the population thereby reducing its potential for harm. Some populations have the capacity to accommodate some catch-and-release or harvest of fish, thus allowable harm from controlled recreational angling (catch-and-release or harvest) may be considered. In cases where harvest is allowed, fishing effort and population status should be monitored regularly and any necessary corrective measures undertaken to ensure the population is not being negatively affected at the population level.

Research activities should be allowed if they are beneficial to the subspecies and will not jeopardize the survival or recovery of a population.

Data and Knowledge Gaps

Completion of surveys to identify all remaining pure native populations and hybridized populations in Alberta is urgently needed. The possibility of using remnant pure native stocks to aid in recovery needs to be evaluated. Obtaining information on abundance, trends and life-history parameters (e.g., recruitment and mortality) for, and current threats to, the remaining populations of pure native Westslope Cutthroat Trout is a high priority. Understanding how they currently use habitat and what anthropogenic stressors they can and cannot accommodate, including prescribed burns or wild fires, is essential to assessing the potential impacts of habitat manipulation. Surveys are needed to identify where spawning and overwintering occurs. It would be helpful to undertake a comprehensive inventory of remaining "pristine", unoccupied habitat that could serve as potential refuge sites for imperiled populations. Surveys of Cutthroat Trout introduced outside of the native range in Alberta could be useful, as those populations may contain the only remaining migratory life-history types.

Sources of Uncertainty

While a concerted effort has been made in recent years to obtain genetic information on Westslope Cutthroat Trout to estimate the degree of introgression at the population level, there are still some uncertainties. Small sample sizes, evolving genetics methods and uncertainty about whether natural polymorphisms exist in some populations have contributed to this problem. There has been debate in the literature about what threshold should be used for deciding that an individual fish or population is pure versus hybridized. Also, advanced-generation backcross hybrids with introgression levels greater than 1% can look

indistinguishable from pure Westslope Cutthroat Trout making it difficult to distinguish between pure and hybrid fish.

Maintaining natural genetic integrity and diversity is critical for the survival and recovery of pure native Westslope Cutthroat Trout in Alberta, yet powerful selective forces have already been at work on the remnant stocks. Populations subjected to such stresses can evolve very rapidly. However, it is unknown whether Westslope Cutthroat Trout can evolve reproductive, behavioural or other isolating mechanisms, with or without assistance, that would reduce or prevent hybridization and/or increase competitiveness with invasive non-indigenous salmonids.

CONCLUSIONS

In Alberta, pure native Westslope Cutthroat Trout have declined in numbers over the past century, though the rate of decline is unknown. Of the 50 extant populations currently identified as pure strain, eight (16%) are currently thought to have a low chance of recovery. It is estimated that most streams contain between 30 and 200 adults (mean: approximately 100), for a total of less than 5,000 mature individuals. Most, if not all, current populations are restricted to the extreme headwaters of a few major tributaries and upper mainstem of the Bow River drainage, and the upper basin of the Oldman River drainage but not in the mainstem east of the mountain front or in most accessible tributaries.

All the geographic areas where they are currently found may be critical for their long-term survival and recovery. Redds created by spawning females for spawning and the initial development of the eggs and alevins meet the SARA definition of residence.

The recovery goal is to protect and maintain all remaining pure native, non-stocked, populations of Westslope Cutthroat Trout in Alberta, each containing at least their current number of fish, with their historical degree of connectivity within drainage systems (except where it would permit invasive non-indigenous species to establish) throughout their current range to ensure their persistence until at least 2020. The aim over the long term is to recover populations within their historic range, where possible.

Invasive non-indigenous species, habitat damage and loss, and climate change pose significant threats to the long-term survival and recovery of pure Westslope Cutthroat Trout. Non-indigenous species introductions pose threats to Westslope Cutthroat Trout through hybridization, competition for resources, predation and possibly the introduction of transferable parasites and disease. Activities related to hydroelectric barriers and impoundments, oil and gas, forestry, mining, agriculture, urbanization, road and rail infrastructure and recreation can damage or destroy habitat and reduce population densities. Climate change may play an important role in limiting the distribution of Westslope Cutthroat Trout in the future through changes in water temperature, patterns of precipitation, stream morphology and hydrology. Overexploitation was an important threat historically, but now is relatively minor.

Important mitigation measures that would improve the current likelihood of survival and recovery of this subspecies include protection of pure native populations from hybridization and competition with non-indigenous species, protection, restoration and enhancement of their habitat, especially by restoring watershed ecological function, and public education (in decreasing order of importance). Recovery efforts for all remaining populations should be prioritized based on current size, importance and a realistic evaluation of prognosis for survival and recovery (i.e., a triage approach).

Activities that have a moderate or higher probability of jeopardizing the survival or recovery of pure native Westslope Cutthroat Trout in Alberta are not recommended. Introductions of invasive non-indigenous species pose severe consequences to pure-strain populations through hybridization, competition and predation and thus are a high risk to survival or recovery where pure remnant Westslope Cutthroat Trout populations remain. Land-use activities that damage or destroy the functional components of habitat or negatively affect key life components of the life cycle (e.g., spawning, recruitment and survival) also have a high risk to negatively impact Westslope Cutthroat Trout populations. Some populations have the capacity to accommodate some catch-and-release or harvest of fish, thus allowable harm from controlled recreational angling (catch-and-release or harvest) may be considered, so long as fishing effort and population status are monitored regularly and any necessary corrective measures undertaken to ensure the population is not being negatively affected at the population level. Research activities should be allowed if they are beneficial to the subspecies and will not jeopardize the survival or recovery of a population.

SOURCES OF INFORMATION

Cleator, H., J. Earle, L. Fitch, S. Humphries, M. Koops, K. Martin, D. Mayhood, S. Petry, C. Pacas, J. Stelfox, and D. Wig. 2009. Information relevant to a recovery potential assessment of pure native Westslope Cutthroat Trout, Alberta population. DFO Can. Sci. Advis. Sec. Res, Doc. 2009/036. iv + 26 p.*

* Revised March 2010

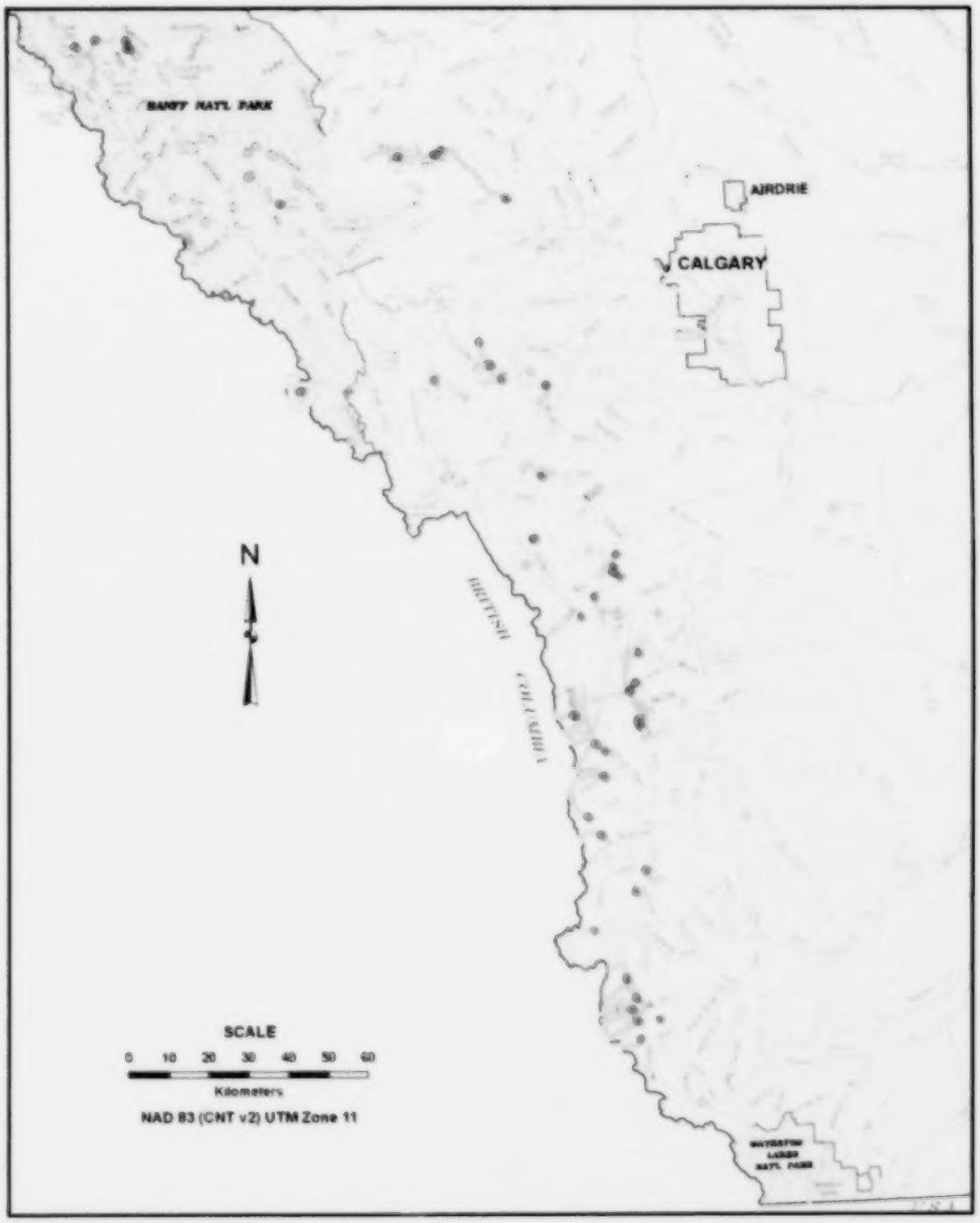

Figure 2. The distribution of pure native (non-stocked) populations of Westslope Cutthroat Trout in Alberta sampled between 2000 and 2008 based on genetic analysis (as of July 2009). Green circles and lines indicate pure strain populations and the potential extent of pure strains, respectively. Orange circles indicate that genetic analysis results are pending. The tertiary watershed boundaries are shown in purple. (©2009 Government of Alberta. All rights reserved. Base Data provided by Spatial Data Warehouse Ltd. The information as depicted is subject to change therefore the Government of Alberta assumes no responsibility for discrepancies at time of use. Alberta Sustainable Resource Development, Southern Rockies Area, Resource Information Unit - Calgary, July 2009)

Table 1. The distribution of known and suspected pure native Westslope Cutthroat Trout (WSCT) populations in Alberta (as of July 2009) based on genetic testing. A pure population is defined as one in which the average of all fish tested was ≥ 0.99 proportion of WSCT genome. Populations marked with an asterisk (*) are those in which pure WSCT were introduced into a waterbody that already contained pure native WSCT. Sample sizes for most populations are relatively small which reduces the degree of confidence about whether the population is pure. Current population (popn) status (see Appendix 1) is defined in terms of the relative size of the population and its distribution, and degree of connectivity. Recovery potential (see Appendix 1) is based on a combination of current population status and current threats status (Table 2). Data sources: McAllister et al. 1981 (a), Carl and Stelfox 1989 (b), Potvin et al., 2003 (c), Janowicz 2005 (d), Robinson 2007 (e), Taylor and Gow 2007 (f), Taylor and Gow 2009 (g). (Note: The methods used to test for genetic purity evolved over time.)

Watershed	Suspected and known pure native WSCT populations	Number of fish tested [data source]	Current popn status	Recovery potential: 2009-2039
Bow/upper Bow River (within Banff National Park, above falls at Banff)	Elk Lake	14 [a], 23 [f]	High	High
	Fish Lake (Upper, Big)	30 [c]	High	Secure
	Little Fish Lake (Lower)	31 [c]	High	Secure
	Deer Lake (Pipestone Lake)*	53 [c]	High	Secure
	Moose Lake	25 [c]	High	Secure
	Bow River, upstream of Hector Lake*	17 [f, g]	Low	Moderate
	Bow River, downstream of Hector Lake*	pending	Low	Low
	Mosquito Creek	23 [f, g]	Low	Moderate
	Outlet Creek	pending	Moderate	Moderate
	Taylor Creek	pending	Low	Low
	Mystic Lake	11 [a], 23 [f]	High	High
	Cuthead Creek	21 [c], 17 [f]	Moderate	Moderate
	Sawback Lake	17 [f]	Low	Low
	Sawback Creek[1]	29 [f]	Moderate	Moderate
Bow/lower Bow River	None			
Bow/Sheep	Gorge Creek, upper*[†]	30 [g]	Moderate	Moderate
Bow/Jumpingpound	Tributary to upper Jumpingpound Creek*[†]	15 [d]	Low	Low
Bow/Elbow	Silvester Creek	23 [d], 27 [g]	Moderate	Moderate
	Tributary to upper Canyon Creek*[†]	19 [d]	Moderate	Moderate
	Prairie Creek*[†]	27 [g]	Moderate	Moderate
Bow/Highwood	Tributary to Flat Creek (Cutthroat Creek)	18 [d], 26 [g]	Moderate	Moderate
	Picklejar Lake #4	26 [b], 29 [g]	High	Secure
	Picklejar Lake #2	26 [g]	High	Secure

[1] Sampled fish were from Sawback Creek but mislabeled in Potvin *et al.* 2003.
[†] Revised March 2010

Watershed	Suspected and known pure native WSCT populations	Number of fish tested [data source]	Current popn status	Recovery potential: 2009-2039
Bow/Highwood (cont.)	Tributary to Flat Creek	30 [g]	Low	Moderate
	Deep Creek	29 [g]	Low	Moderate
	Zephyr Creek	30 [g]	Low	Moderate
	Etherington Creek, below seasonal barrier*†	30 [g]	Moderate	Moderate
Bow/Kananaskis	Evan-Thomas Creek*†	55 [d]	Low	Low
Bow/Ghost	Waiparous Creek*†	11 [g], 29 [g]	Moderate	Moderate
	Johnson Creek	17 [g]	Moderate	Moderate
Bow/Spray	None			
Oldman/upper Oldman	Oldman River, above falls*‡†	25 [g], 59 [e]	Moderate	High
	Oldman River, immediately below falls*‡†	21 [g]	Moderate	Moderate
	Oyster Creek	17 [d]	Moderate	High
	Honeymoon Creek	56 [e]	Low	Moderate
	Hidden Creek, above falls*‡†	27 [g]	Moderate	Moderate
	North Racehorse Creek, above falls	28 [g], 30 [e]	Moderate	Moderate
	Dutch Creek*†	14 [d, e]	Moderate	Moderate
	Daisy Creek, above falls*‡†	20 [d]	Moderate	Moderate
Oldman/mid Oldman	None			
Oldman/Livingstone	Livingstone River, above falls*‡†	58 [e], 27 [g]	Moderate	Moderate
	Livingstone River, below falls*‡†	63 [e]	Moderate	Moderate
	North Twin Creek	19 [d]	Low	Moderate
	Beaver Creek	60 [e]	Moderate	Moderate
Oldman/Crowsnest	Blairmore Creek, upper above falls*‡†	20 [d]	Moderate	Moderate
	Tributary to Crowsnest River	30 [g]	Low	Low
Oldman/Castle	Lost Creek*†	28 [g]	High	Moderate
	Carbondale River*†	22 [g]	High	Moderate
	Lynx Creek, above falls*‡†	14 [f], 15 [d]	High	Moderate
	O'Hagen Creek	30 [g]	Moderate	Moderate
	Gardiner Creek*†	29 [g]	Low	Moderate
Oldman /lower mainstem	None			
Oldman/Willow	Corral Creek	30 [g]	Low	Low
	Iron Creek*†	2 [g]	Low	Low
Oldman/St Mary	None			
Oldman/Belly	None			

† Revised March 2010
‡ Stocking location is unknown; may have been above or below the falls.

Table 2. Current status of threats to pure native Westslope Cutthroat Trout by population, defined in terms of the likelihood of occurrence and level of severity, based on current knowledge of the populations and the areas in which they occur. (L = low, M = moderate, H = high, U = unknown)

	THREATS										
	Invasive non-indigenous species	Habitat loss or degradation								Climate	Consumptive use
POPULATIONS	Introduced salmonid species[1]	Hydroelectric barriers/ impoundments and activities[2]	Oil and gas exploration/ extraction[2]	Forestry exploration/ extraction[2]	Mining exploration/extraction[2]	Agricultural activities[2]	Urban development[2]	Road and Rail Infrastructure[2]	Recreation[3]	Climate change[4]	Over-exploitation[5]
Elk Lake	L	L	L	L	L	L	L	L	L	U	L
Fish Lake (Upper, Big)	L	L	L	L	L	L	L	L	L	U	L
Little Fish Lake (Lower)	L	L	L	L	L	L	L	L	L	U	L
Deer Lake (Pipestone Lake)	L	L	L	L	L	L	L	L	L	U	L
Moose Lake	L	L	L	L	L	L	L	L	L	U	L
Bow River (upstream Hector Lake)	M	L	L	L	L	L	L	L	L	U	L
Bow River (downstream Hector Lake)	H	L	L	L	L	L	L	L	L	U	L
Mosquito Creek	M	L	L	L	L	L	L	L	L	U	L
Outlet Creek	L	L	L	L	L	L	L	L	L	U	L

[1] Threats include predation by, and competition for resources with, Rainbow Trout, Brook Trout, Brown Trout, Lake Trout, Yellowstone Cutthroat Trout and hatchery-raised Westslope Cutthroat Trout (WSCT). Hybridization of pure native WCT with some of these species is also resulting in the loss of pure WSCT strains.

[2] Threats include changes in flow regime, frazil and anchor ice, water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.

[3] Threats include off-highway vehicle use causing riparian disturbance, stream sedimentation, channel damage, etc.

[4] Threats include changes in water temperature, patterns of precipitation, stream morphology and hydrology.

[5] Illegal harvest - intentional (e.g., poaching) and unintentional (e.g., misidentification) - and hooking mortality (bycatch) in waterbodies closed to harvest of pure native WSCT.

POPULATIONS	Introduced salmonid species	Hydroelectric barriers/ impoundments and activities	Oil and gas exploration/ extraction	Forestry exploration/ extraction	Mining exploration/extraction	Agricultural activities	Urban development	Road and Rail Infrastructure	Recreation	Climate change	Over-exploitation
Taylor Creek	H	L	L	L	L	L	L	L	L	U	L
Mystic Lake	L	L	L	L	L	L	L	L	L	U	L
Cuthead Creek	U	L	L	L	L	L	L	L	L	U	L
Sawback Lake	L	L	L	L	L	L	L	L	L	U	M
Sawback Creek	H	L	L	L	L	L	L	L	L	U	L
Gorge Creek, upper	H	L	L	M	L	L	L	L	L	U	L
Tributary to upper Jumpingpound Creek	H	L	L	M	L	L	L	L	L	U	L
Silvester Creek	M	L	M	M	L	M	L	M	M	U	L
Tributary to upper Canyon Creek	M	L	L	M	L	L	L	M	L	U	M
Prairie Creek	M	L	L	L	L	M	L	M	L	U	M
Tributary to Flat Creek (Cutthroat Creek)	M	L	M	L	L	M	L	L	L	U	L
Picklejar Lake #4	L	L	L	L	L	L	L	L	L	U	M
Picklejar Lake #2	L	L	L	L	L	L	L	L	L	U	M
Tributary to Flat Creek	M	L	L	L	L	M	L	L	L	U	L
Deep Creek	M	L	M	L	L	M	L	L	L	U	L
Zephyr Creek	M	L	L	L	L	M	L	L	L	U	L
Etherington Creek, below seasonal barrier	H	L	L	M	L	L	L	L	L	U	L
Evan-Thomas Creek	H	L	L	L	L	L	L	L	L	U	L
Waiparous Creek	H	L	L	L	L	L	L	M	M	U	M
Johnson Creek	H	L	L	L	L	L	L	M	M	U	L
Oldman River, above falls	M	L	M	M	L	M	L	H	H	U	L
Oldman River, immediately below falls	H	L	M	M	L	M	L	H	H	U	L
Oyster Creek	M	L	M	M	L	M	L	H	H	U	L
Honeymoon Creek	H	L	M	M	L	M	L	M	H	U	L

POPULATIONS	Introduced salmonid species	Hydroelectric barriers/ impoundments and activities	Oil and gas exploration/ extraction	Forestry exploration/ extraction	Mining exploration/extraction	Agricultural activities	Urban development	Road and Rail Infrastructure	Recreation	Climate change	Over-exploitation
Hidden Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
North Racehorse Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
Dutch Creek	H	L	M	M	L	M	L	H	H	U	L
Daisy Creek, above falls	H	L	M	M	L	M	L	H	H	U	L
Livingstone River, above falls	M	L	M	M	L	M	L	H	H	U	L
Livingstone River, below falls	H	L	M	M	L	M	L	H	H	U	L
North Twin Creek	H	L	M	M	L	M	L	H	H	U	L
Beaver Creek	M	L	M	M	L	M	L	L	H	U	L
Blairmore Creek, upper above falls	H	L	M	M	L	M	L	H	H	U	L
Tributary to Crowsnest River	M	L	L	L	L	M	L	L	L	U	L
Lost Creek	H	L	M	M	L	M	L	H	H	U	L
Carbondale River	H	L	M	M	L	M	L	H	H	U	L
Lynx Creek, above falls	M	L	M	M	L	M	L	H	H	U	L
O'Hagen Creek	L	L	L	M	M	M	L	M	M	U	L
Gardiner Creek	H	L	M	M	L	M	L	L	H	U	L
Corral Creek	H	L	M	M	L	M	L	L	M	U	L
Iron Creek	H	L	M	M	L	M	L	L	M	U	L

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